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U.S. Department of Agriculture
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ABSTRACT

1. An Aerial Dispenser for Viscous Lure-Toxicant Mixtures. A viscous lure-toxicant dispenser has been developed and tested in the fruit fly control program, using male annihilation to depress the population. The dispenser was designed to fit into a small airplane so that leased aircraft can be employed in the tests and pilot projects conducted worldwide. This installation has been certificated by the Federal Aviation Administration. With the aircraft flying at 50 to 500 ft above the terrain, the dispenser deposits 10-ft-wide bands of viscous droplets that adhere to the foliage. Lines of flight are spaced 200 ft to one-half mile apart to treat large areas. In several pilot studies with the melon fly (*Dacus cucurbitae* Coquillet) and the oriental fruit fly (*Dacus dorsalis* Hendel) in the Hawaiian Islands, better than 90-percent male insect control was achieved, with residual action lasting more than 2 weeks in a tropical humid climate.

2. An Aerial Dispenser of Cigarette Filters Treated With Lure-Toxicant Mixtures. A dispenser has been developed and tested for the aerial application of cigarette filters impregnated with a lure and a toxicant for an experimental program to control fruit flies in Hawaii. This paper describes the design and construction of the dispenser, the results of calibration tests at Yakima, and some performance tests in Hawaii.

KEYWORDS: Lure, toxicant, viscous lure-toxicant, fruit fly control, airborne dispenser, viscous pump, dispenser, particle dispenser, cigarette filter dispenser.

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TROPICAL FRUIT FLY CONTROL

By P. A. Boving, R. T. Cunningham, and R. G. Winterfeld[1]

1. An Aerial Dispenser for Viscous Lure-Toxicant Mixtures

BACKGROUND OF THE PROBLEM

Exploration into newer and more selective methods of pest control (*5*, *6*)[2] has led to the formulation of a lure and a toxicant in a viscous base for the control of selected species of tropical fruit flies. This formulation is used to reduce uncontrolled wild populations so that releases of sterile insects can maintain dominance over the wild populations. Without this step, a massive release program would be needed initially to overpower the wild population. The isolation of male lures (*1*, *3*) makes the formulation more specific; and, with other protective materials, the formulations now provide: (a) a vehicle for attaching small quantities of chemicals to plant surfaces, (b) protection of the chemicals from atmospheric and soil breakdown forces, and (c) a slow release of the chemicals to extend their effectiveness.

DESIGN PARAMETERS

The equipment is designed to be mounted in a variety of aircraft. Power requirements are 12 volts d.c. at 30 amps to make use of the aircraft power supply. Additional power, to move the viscous material from the supply tank, is provided by CO_2 gas under pressure. Component weights are limited to 150 lb so that the assemblies could be mounted on the seat tracks and use the seatbelt attachment points as anchors. (See fig. 1.) The dispenser design calls for lightness to obtain the greatest payload of formulation and strength to withstand possible shock resulting from violent maneuvers. The design has been certificated by the Federal Aviation Administration for specific aircraft to allow the greatest use of this equipment in research studies and control projects. The dispenser consists of a supply tank, a metering pump, and a discharge hose with a valve at the end to prevent dripping.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 6.

Figure 1.--Viscous tank and pump unit installed on seat tracks of aircraft.

The viscous agents used in formulations with this equipment are thixotropic, exhibiting a mayonnaiselike consistency when freshly mixed. When allowed to stand for 12 hours (overnight), these agents develop a lardlike consistency at room temperature. This characteristic requires the use of a positive metering device to control the flow rate. Starting friction is high until the material is "worked" into its lower viscous state. In earlier experiments with thicken-

ers, protein hydrolyzates and monoglycerides of lard were used, whereas in later experiments the dispenser was tested with Cab-O-Sil® and Thixcin E® (*3*, *4*). Since the lure-toxicant mixture attacks ordinary rubbers and neoprene, Nitrile "O" rings and Teflon-lined hoses are used to contain the mixtures. Carbon steels rust badly where they come in contact with these mixtures and are left out in the humid tropical climate. Early tests showed that multiple outlets can not be used with this viscous material because if an outlet plugs once, it might not open again if the mixture could escape elsewhere. Droplet size has to be great enough to insure lethal doses of toxicant (about ¼-inch-diameter "blob" attached to a surface) yet not be so large that material would be wasted.

DESCRIPTION OF THE EQUIPMENT

The supply tank is fabricated from a 8-inch-diameter seamless aluminum pipe with a 1/8-inch-wall thickness, anodized to resist corrosion. The aluminum base and top ring are clamped to the tank wall with six ¼-inch-stainless steel rods. These rods extend beyond the top ring to hold the lid on with wingnuts. The bottom, top ring, and lid are machined from ½-inch-aluminum stock, and the base and top ring are sealed to the tank wall with Viton "O" rings. The formulation is delivered to the metering pump from the base of the tank. A follower plate, sliding on a 1-inch-diameter pipe shaft inside the tank, separates the air chamber (follower plate to lid) from the formulation chamber (follower plate to base). The tank component dimensions were checked, and the vessel was pressure-tested to 150 psi using air. The maximum operating pressure was set at 75 psi. In operation, a CO_2 fire extinguisher cylinder, connected to a pressure regulator to limit the pressure, is coupled to the tank lid to force the follower plate against the formulation to deliver it to the metering pump.

The metering pump is a precision gear pump (Zenith Model BC 4913, used for extruding polymer filaments), whose output rate is proportional to the speed of rotation. The pump is driven by a 1/3-hp variable speed transmission (Zeromax Model JK-1), using twin positive-drive belts with a 15:44 stepdown pulley ratio. This ratio converts the transmission output speed of 0 to 400 revolutions per minute (r/m) to a 0- to 136-r/m range for the pump. The transmission is driven by a pair of 1/5-hp 12-volt d.c. motors, wired in parallel, using positive-drive belts to connect the motors to each other and to the transmission. A 22:46 stepdown pulley ratio provides a transmission input speed of 1750 r/m when the motors are running at 3600 r/m (approximately one-half load speed). The unit is shown in figure 2.

Teflon hoses with braided steel wire shields carry the viscous formulation from the tank to the pump with a 1-inch-diameter hose and from the pump to the nozzle with a ½-inch-diameter hose. A heavy-duty push-pull cable (marine outboard steering control cable) controls a slide valve on the end of the discharge hose. A short (6 inches) section of ½-inch-pipe is coupled to the valve to provide an outlet free of obstructions to the airflow. The cable control and the power switch for the metering pump are interlocked so that the pump runs only when the valve is fully open.

The pump speed (and thus, the output rate) is indicated by a self-powered tachometer (Sun Model WU-IA) geared to the transmission output shaft.

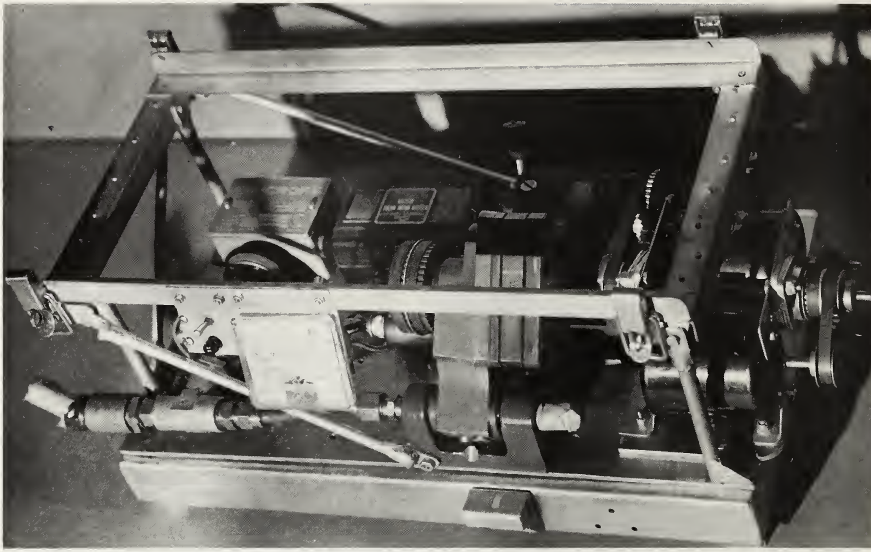

Figure 2.--Pump unit and mounting frame for holding supply tank.

The pumping unit is installed on seat tracks in the aircraft, and the supply tank unit is clamped to a frame over the pump unit. The CO_2 cylinder and regulator are strapped into the rear seat with the seatbelt. The 1-inch hose delivers the formulation from the tank to the metering pump. The discharge hose, starting at the rear of the pumping unit, passes behind the pilot's seat, exits through the pilot's window, and terminates on the left landing gear leg (see fig. 3). This location prevents the formulation touching the tail surfaces and fuselage and also allows the pilot to observe the action of the nozzle.

OPERATIONAL TESTS

Bench tests of the dispenser were made using medium weight automotive grease as a substitute for the actual formulation. The materials would be expensive, and the toxicants require special handling. With the transmission at full speed (400 r/m), we got a maximum discharge rate of 94 in^3/min (1500 ml/min) with a pump speed of 136 r/m.

Flying at 1,000 ft above the ground, and under calm conditions, the formulation lands on the ground in a band or swath about 10 ft wide. At 10 ft above the ground, the width of the band is less than 1 ft. The largest droplet size (diameter of mark on a target surface) is about 5/8 inch across.

FIELD TESTS IN HAWAII

For several years, experimental applications were made to test improved versions of the dispenser as well as various formulations of viscous lure-toxicants. The results reported below are not to be considered a recommended practice (*2*).

In 1973, Cue-lure was used against the melon fly, *Dacus cucurbitae* Coquillet, in a formulation of 60-percent Cue-lure, 30-percent naled[3] (a biodegradable organo-phosphate insecticide), and 10-percent Thixcin E® thickener (*3*). This was applied to a 2.7-mi^2 area by air at 50 to 330 ft elevation (using a swath spacing of about 200 ft, a speed of 100 mi/h, and a discharge rate of 13 oz/min, to apply 12.3 lb/mi^2) and resulted in a 98-percent reduction in male population that lasted almost 2 weeks.

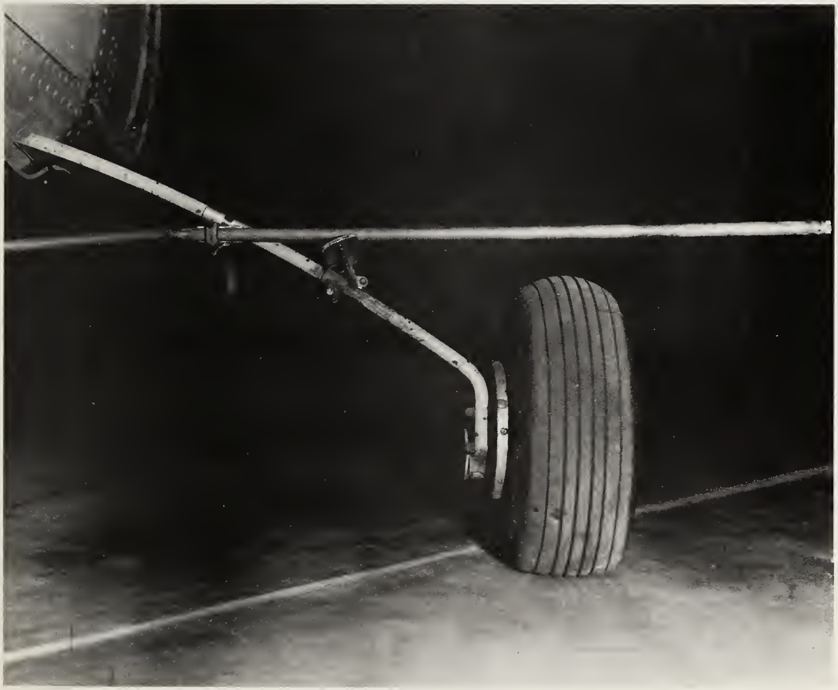

Figure 3.--Discharge wand, mounted to aircraft landing gear leg, to which discharge hose and the valve are connected at each end.

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[3]1,2-dibromo-2,2-dicholoroethyl dimethyl phosphate.

We treated 120 mi^2 of a 145-mi^2 area at 100 to 500 ft elevation, using a swath spacing of either 0.1 mi or 0.5 mi (depending on drift conditions and probable density of the fly population) and a speed of 120 mi/h. An average overall application rate of 1.01 lb/mi^2 resulted an area-wide reduction in male fly population of 93 percent.

In 1976, in a test against the oriental fruit fly, *Dacus dorsalis* Hendel, a mixture of 58-percent methyl eugenol (lure), 25-percent naled (toxicant), and 17-percent Thixcin E (thickener) was applied to 2.3 mi^2 by air. The formulation was applied in bands at the rate of 12 lb/mi^2, and resulted in an immediate reduction in male insect population of 98 percent, that was still greater than 90 percent 2 months later.

CONCLUSIONS

A dispenser has been developed and tested for the aerial application of a lure-toxicant in a viscous medium. The viscous medium allows the lure-toxicant in a viscous medium. The viscous medium allows the lure-toxicant to have an extended life and to withstand tropical, humid climates. Using a pipe outlet, the formulation can be distributed in narrow bands that can be used either as (1) line or boundary control, or (2) area control of an active insect using suitable lure-toxicant concentration and swath or band spacing.

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(6) ________ Hart, W. G., Harris, E. J. and others.
1970. Eradication of the oriental fruit fly from the Mariana Islands by the methods of male annihilation and sterile insect release. Journal of Economic Entomology 63:131-135.

2. An Aerial Dispenser of Cigarette Filters Treated with Lure-Toxicant Mixtures

INTRODUCTION

For several years, entomologists in Hawaii have been experimenting with sterile insect releases to control tropical fruit fly populations.[1] [2] They found that they needed either massive overpowering releases to make the sterile insect release successful, or else they had to start with low or reduced populations of wild insects. To reduce populations of wild insects, they explored the technique of male annihilation, using formulations of toxicants. To be successful, these formulations needed to have an extended life and to withstand the tropical humid climate. Treatments had to be applied by air to cover areas quickly and to reach terrain usually inaccessible by ground. Early experiments with fiberboard squares treated with lure-toxicant formulations showed the potential of this technique. Cigarette filters were later selected as a smaller and less expensive carrier than the squares. A hopper and a metering device were required for installation in an airplane that would discharge the treated filters through a hatch centered in the floor of the aircraft behind the pilot's seat.

DESIGN AND CONSTRUCTION

Hopper and Auger

Initial experiments were conducted with an auger in a vertical tube fitted to the bottom of a conical hopper. We wanted to determine the length of auger needed to meter the flow of filters when the auger rotated and to hold the filters when the auger was stopped.

We designed a circular hopper with a tapered bottom and concentric discharge tube for maximum capacity (60,000 filter tips) that could still be installed as a single unit in the aircraft to prevent leakage of the lure toxicant. The hopper and discharge tube were molded from fiberglass. Steel connectors for the legs were bonded to the hopper at four points, 90° apart, with glass mat and resin. A metal ring was bonded to the bottom of the discharge tube. A circular lid, fabricated from a 0.125-inch aluminum sheet, was attached to the top of the hopper by glass mat and resin. The lid served as a cover and also as a platform for the upper auger bearing and the motor drive. A portion of the lid was hinged (a sector of the circle) for filling the hopper when installed in the aircraft.

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[1]Steiner, L. F., W. C. Mitchell, E. J. Harris, and others. Oriental fruit fly eradication by male annihilation. Journal of Economic Entomology 58:961-964. 1965.

[2]Steiner, L. F., W. G. Hart, E. J. Harris, and others. Eradication of the oriental fruit fly from the Mariana Islands by the methods of male annihilation and sterile insect release. Journal of Economic Entomology 63:131-135. 1970.

A seal plate was added to the bottom of the discharge tube below the lower auger shaft bearing to prevent any liquid drainage from the filters being discharged when the auger was shut off. This plate seated against the ring collar and was moved by a rod sliding vertically inside the auger shaft. The dispenser components are detailed in figures 1 to 7.

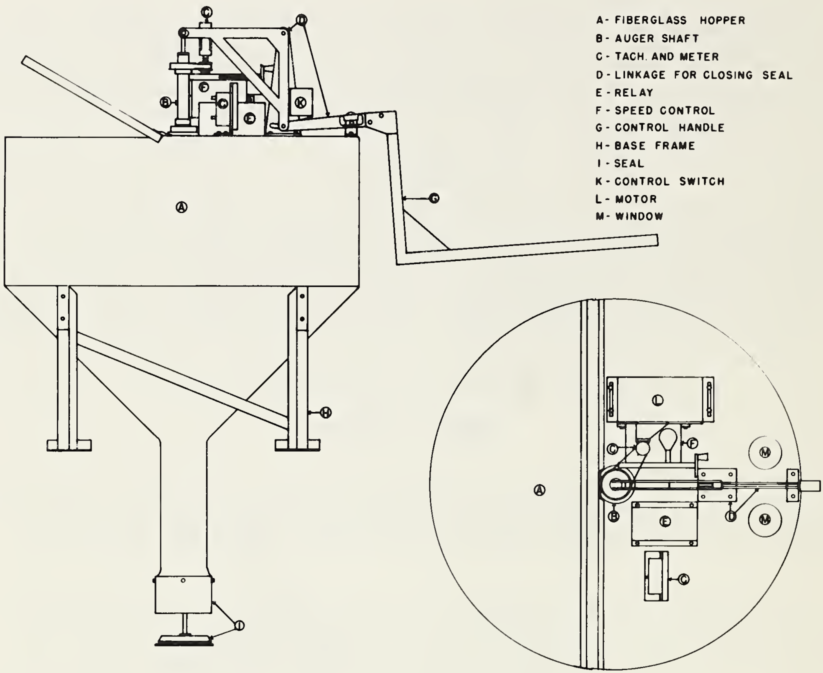

Figure 1.--Auger dispenser drawing No. 1, assembly view.

The dispenser was initially fitted with a mild steel[3] auger and shaft. This was later discarded because it developed problems. Two stainless steel augers, with 1-inch shafting and 3-inch pitch flighting, were built. The larger auger had an outside diameter of 2-7/8 inches and the smaller was 2-3/8 inches in diameter to fit inside the 3-inch fiberglass discharge tube. We wished to compare the performance of these augers under full test conditions in Hawaii before selecting the more trouble-free auger.

Text continues on page 13.

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[3] A form of carbon steel in common use in steel fabrication. It welds and machines readily but rusts and is easily attacked by acids and alkalis.

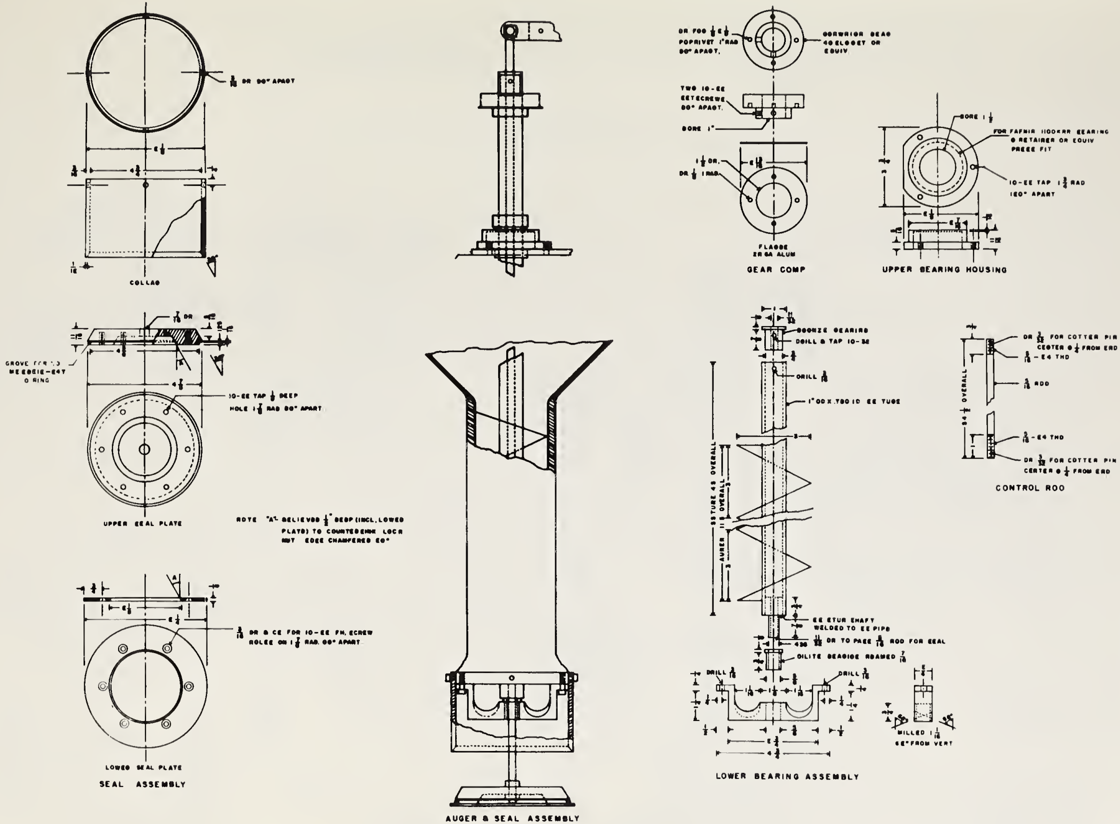


Figure 2.--Auger dispenser drawing No. 2, auger seal and assembly.

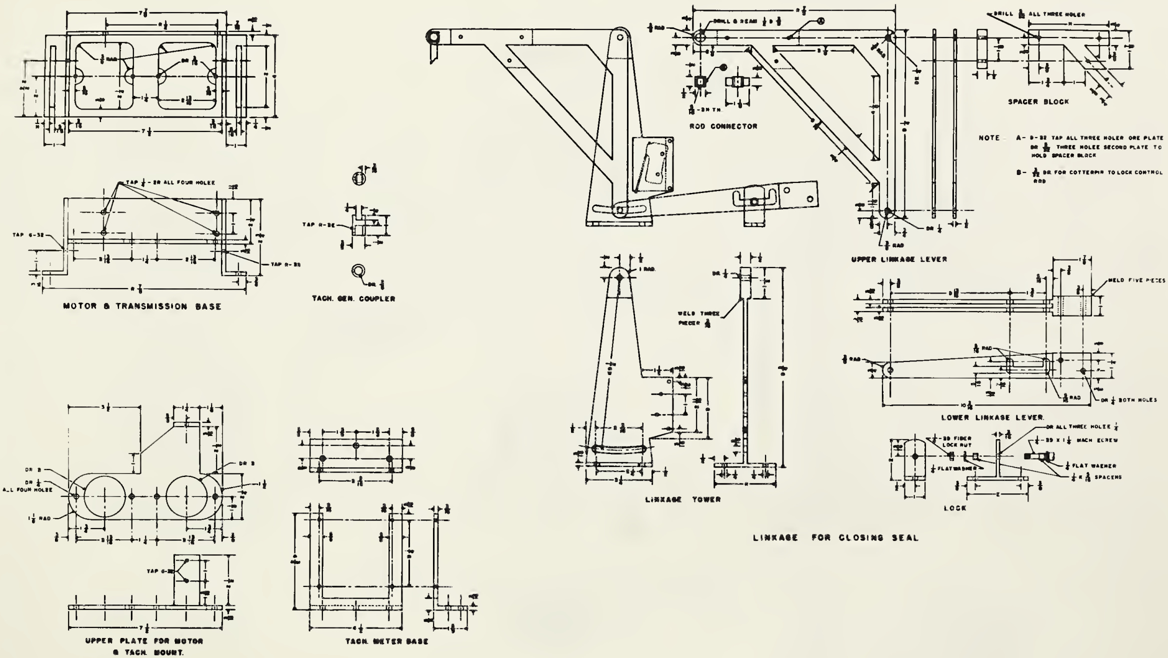


Figure 3.--Auger dispenser drawing No. 3, linkage and motor mount components.

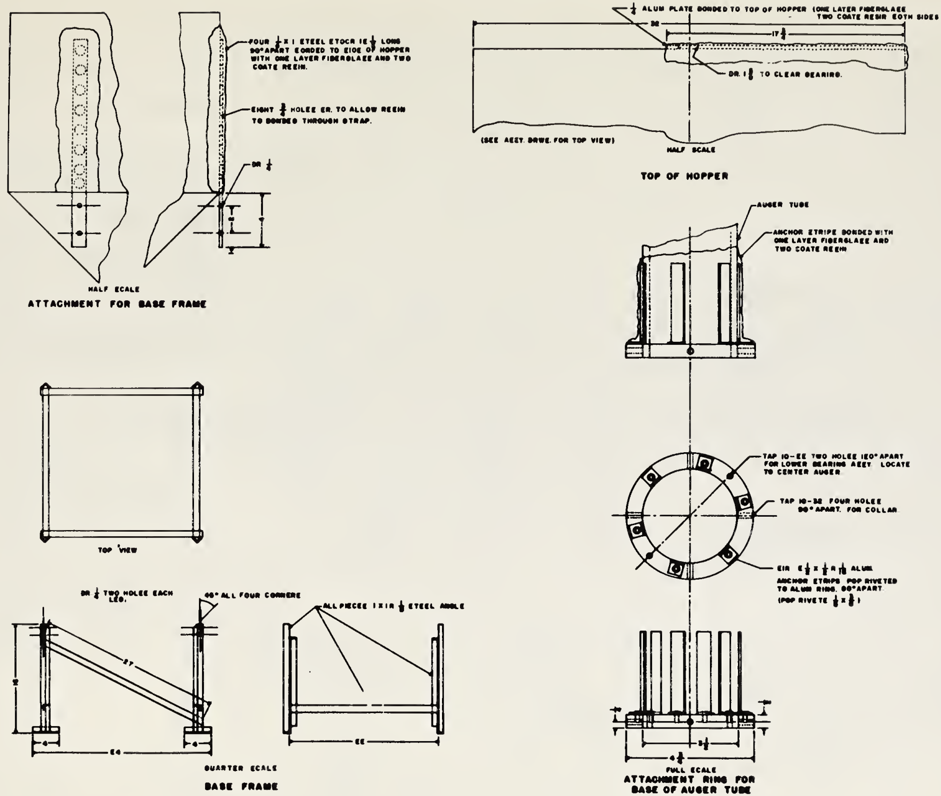
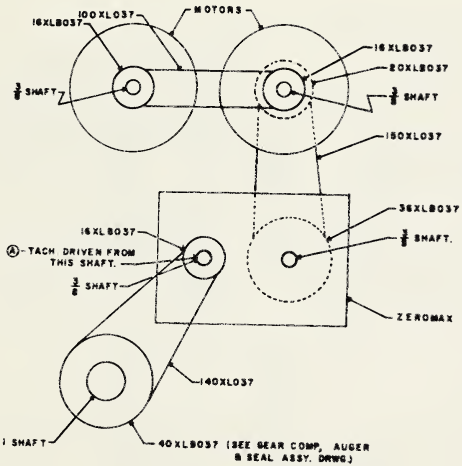


Figure 4.--Auger dispenser drawing No. 4, component assembly.



MOTOR — TWO EVERHOT SMALL AUTOMOTIVE. NO.-M-898 12 VDC OR EQUIV.

ZEROMAX - JK2 CW 0-400 OR EQUIV.

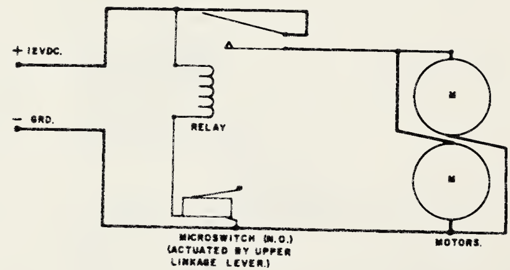
BELTS & GEARS - STOCK NOS. FOR BROWNING POSITIVE DRIVE OR EQUIV.

TACHOMETER - SERVO-TEK TYPE SA-757B1 20.8 V/1000 R.P.M. OR EQUIV.

INDICATOR MADE FROM AMP. METER WITH SCALE CALIBRATED DIRECT.

Ⓐ- SEE TACH. GEN. COUPLER, LINKAGE & MOTOR MOUNT DRWG.

DRIVE COMPONENTS.



RELAY - 12VDC SPDT 25 AMP POINTS. POTTER & BRUMFIELD - PDR-5DYO-12 OR EQUIV.

MICROSWITCH - 15 AMP AT 125 VAC. MICRO - BZ-RW04 OR EQUIV.

WIRING DIAGRAM

Figure 5.--Auger dispenser drawing No. 5, drive components and wiring diagram.

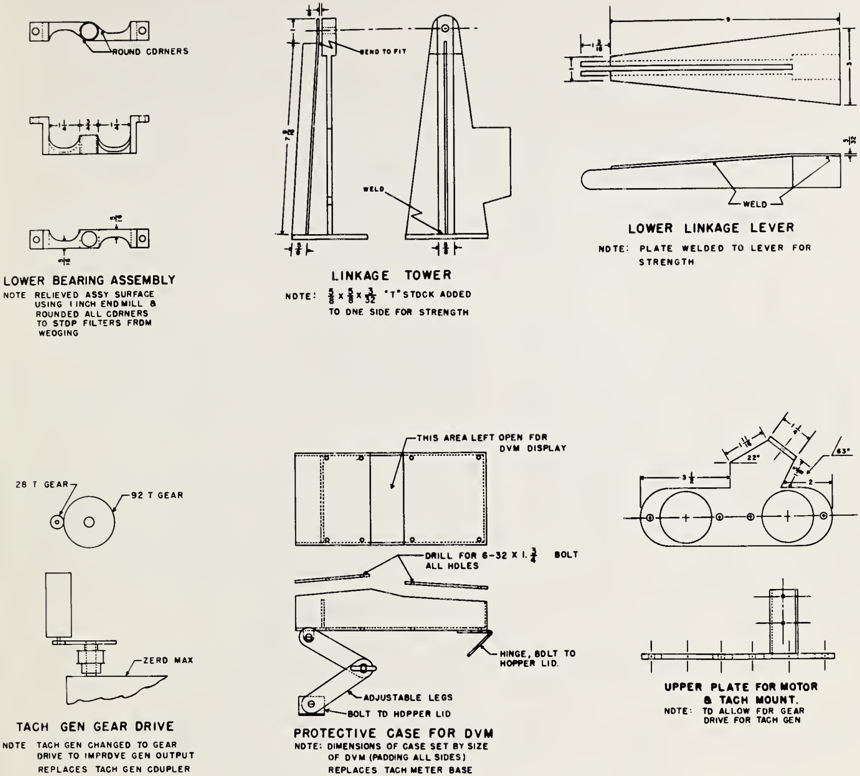
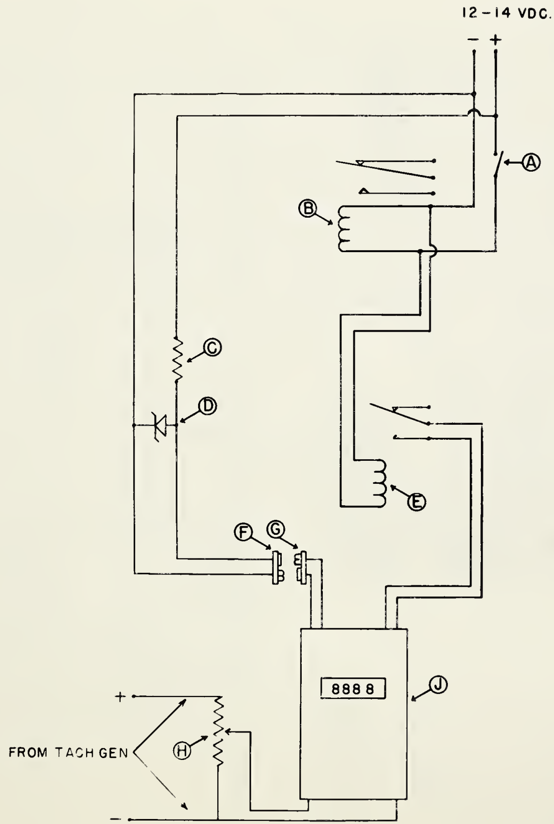


Figure 6.--Auger dispenser modification No. 1, changes to tachometer.

Auger Drive

The auger drive system used two 1/5-horsepower, 12-volt d.c. motors wired in parallel and coupled by a belt to drive a 1/3-hp variable speed transmission. The output of the transmission drove the auger by a positive-drive belt and a d.c. generator-tachometer by gears. The tachometer was calibrated to indicate the auger speed directly because there was no slippage in the drive system. The fastest transmission setting drove the auger at 120 revolutions per minute (r/m).



A. MICROSWITCH.

B. MOTOR RELAY.

C. RESISTOR-100 OHM 1 WATT.

D. ZENER DIODE - ECG 139 (OR EQUIV.) 9V 1W

E. ON-OFF RELAY FOR DVM (1200 OHM COIL 1 AMP. POINTS SPDT) R/S 275-003 (OR EQUIV.)

F. 9V BATTERY CONNECTOR. R/S 270-325 (OR EQUIV.)

G. EXISTING BATTERY CONNECTOR FOR DVM.

H. 50K TRIMPOT FOR CALIBRATION.

J. MICRONTA DIGITAL VOLTMETER. (R/S 22-199)

NOTE: C&D SUPPLYS 9V. TO DVM. FROM 12V POWER SUPPY.

F IS A 9V BATTERY CONNECTOR WIRED IN REVERSE TO COUPLE WITH G.

MICRONTA DVM. SET FOR DCV. X10 WIRED DIRECTLY TO CCT BOARD FROM 50K TRIMPOT (H). POWER SW. DISCONNECTED AND WIRES BROUGHT OUT TO RELAY (E).

Figure 7.--Auger dispenser modification No. 2, motor mount changes.

INITIAL TESTS AND CALIBRATION OF DISPENSER

In shop tests using cigarette filters treated with ethylene glycol to represent the lure-toxicant, these filters would bridge around the auger shaft, cutting off the flow. This problem was solved by attaching a coil spring to the auger shaft about 1¼ inches above the auger. The spring, 3/8 inch in diameter and 15 inches long, was stiffened at the supporting end by inserting a 3-inch piece of 1/8-inch brazing rod and brazing the end of the spring to the rod. The rod was then bent and clamped to the auger shaft so that the spring would just contact the sloping wall of the hopper where the auger rotated. The top of the auger had to be kept one-half inch below the junction of the hopper and the discharge tube to avoid wedging filters between the edge of the auger and the wall of the tube.

Using ethylene glycol treated filters, we tested the large- and small-diameter stainless steel augers for the delivery rates and found that the small auger delivered 3 to 10 percent more filters than the larger one, and that the small auger was essentially jam proof. Later tests in Hawaii, in which we used filters soaked in lure-toxicant, supported this finding.

The dispenser was calibrated in the shop for delivery rates using the smaller auger and Filtrona "recuts" (cigarette filters with skins or covers described in the next section) soaked in water. Replicated tests were run (five replications for tests from 1 to 40 r/m, and three replications for 50 to 90 r/m), and a regression analysis was made comparing delivery rates to auger speed. We obtained the equation.

$$Y = -59.7 + 61.3\,X$$

where Y = number of filters dispensed per minute
X = revolutions per minute of auger shaft

We obtained a coefficient of correlation (r^2) of 0.9991. This high degree of correlation shows that the dispenser performed well at auger speeds up to 90 r/m. These delivery rates are plotted in the graph in figure 8.

While constructing the hopper, we tested a dummy discharge outlet on an airplane to see if the filters would come in contact with the fuselage and elevator surfaces. Using filters soaked in dye, we found marks on the aircraft. We then designed and installed a 24-inch horizontal duct discharging to the left and back 45°, which eliminated the problem. The duct was rectangular and was encased in a streamlined fairing as shown in figures 9 and 10.

Several field tests, using filters soaked in water, were made near Yakima with the dispenser installed in the airplane. We wished to check the field operation rates against the shop calibration values at the lower rates of application. We found that at rates below 20 r/m auger speed, the output was not uniform, tending to discharge clumps of filters; but that some individual field runs equalled the shop test rates for that auger speed. This test showed that the shop calibration could be used as guide for output rates. Since the "slipperiness" of each chemical will vary, it is recommended that calibration trials be made for each material.

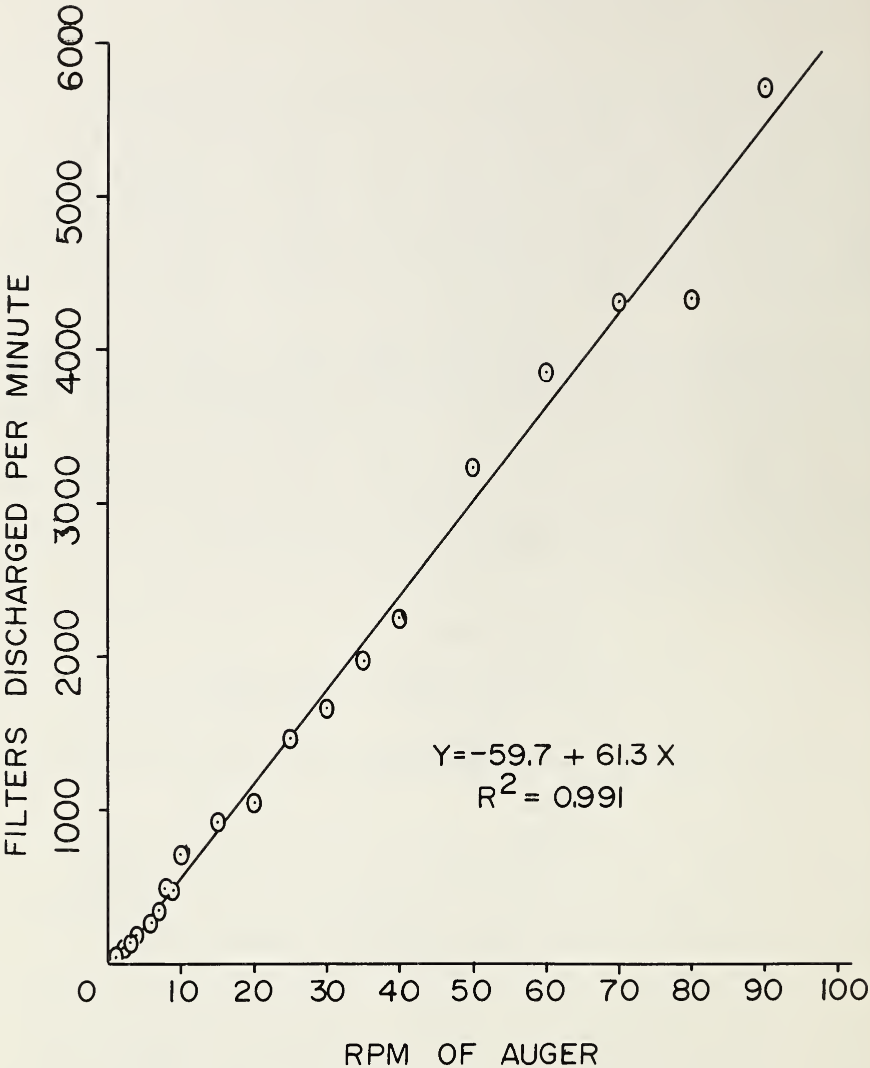


Figure 8.--Plot of regression curve and calibration of dispenser.

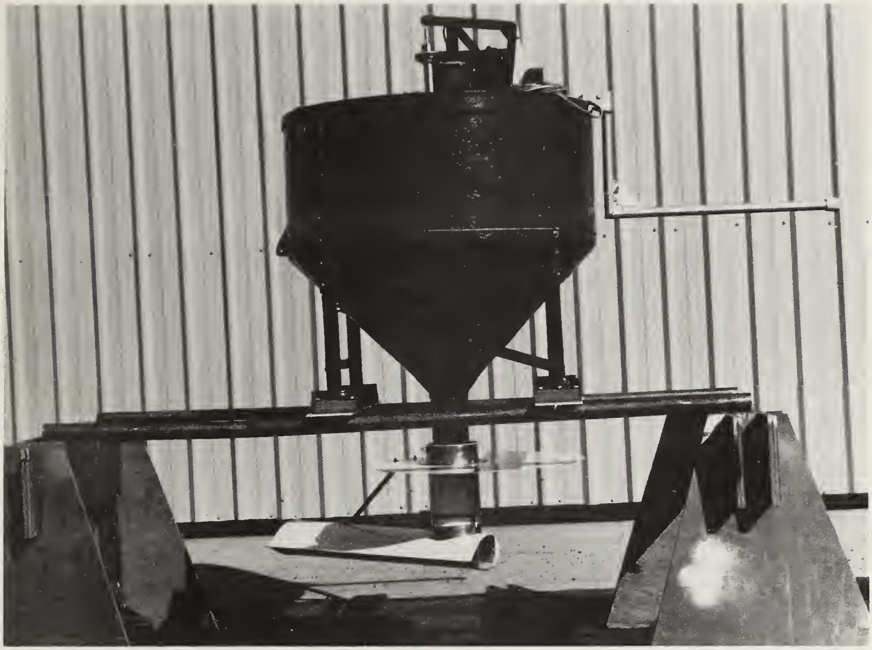


Figure 9.--View of completed dispenser.

FIELD TESTS IN HAWAII, 1978-79

Seven applications were made to selected areas of the island of Lanai for the control of the oriental fruit fly, *Dacus dorsalis* Hendel, shown in table 1. A mixture of 25-percent malathion[4] in methyl eugenol solution (toxicant and lure, respectively) was allowed to soak into cigarette filter tips. Two types of filter tips were used: (1) Skinless Filtrona tips (R5547), 4/5 inch long by 2/5 inch in diameter, and (2) wrapped Filtrona "recuts," 4/5 inch long by 3/10 inch in diameter. Applications were made at 120 miles per hour and at heights of 30 to 500 ft elevation above ground with a leased airplane. The test areas were located in remote valleys and forested areas to study the control of this insect by male annihilation. Applications were flown in bands or swaths 300 to 500 ft apart.

[4]Diethyl mercaptosuccinate *s*-ester with *O*,*O*-dimethyl phosphorodithioate.

Figure 10.--Dispenser installed in aircraft.

Table 1.--*Summary of the Hawaiian plot tests*

Test No.	Filter type[1]	Auger	Date applied	Area covered	Filters
				Square miles	*No./acre*
1	a	Large	4/ 4/78	3.9	29.4
2	a	--do--	5/31/78	1.2	4.3
3	b	--do--	9/19/78	1.2	11.5
4	b	--do--	10/24/78	2.8	8.8
5	b	--do--	11/21/78	2.8	26.5
6	b	Small	12/19/78	2.7	27.4
7	b	--do--	2/27/79	2.8	14.0

[1]a, Skinless Filtrona tips; b, wrapped Filtrona "recuts."

In one test, flown at treetop height, the filters were found in a band not more than 25 ft wide. In another test, flown about 300 ft above the vegetation, the bank width did not exceed 75 ft. At auger speeds below 20 r/m, jamming occurred occasionally with both augers. This was overcome by relocating the agitator spring. Since the entomologists in Hawaii were testing methods of impregnating the filter tips and rates of application of treated filter tips, the biological effectiveness of these applications will be reported elsewhere.

SUMMARY

A cigarette filter dispenser has been developed for releasing treated filters from an aircraft for controlling insect pests. The machine is driven electrically from the aircraft's 12-volt d.c. power system and draws less than 25 amps. The delivery rate is adjustable from 750 to 6,000 filter tips per minute, and the hopper holds about 60,000 filter tips. With extremeley low delivery rates (below 10 r/m auger speed), we observed poor uniformity of delivery. We found that the swath width did not exceed 25 ft when flown at treetop height or 75 ft when flown at about 300 ft elevation. The treated filter technique for controlling mobile insects that are attracted to baits should avoid the problems associated with spray applications of toxicants.

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